7MHz, Rail-to-Rail I/O CMOS Operational Amplifier

1 FEATURES

- **Qualified for Automotive Applications**
- **AEC-Q100 Qualified with the Grade 1**
- **HIGH GAIN BANDWIDTH:7MHz**
- **RAIL-TO-RAIL INPUT AND OUTPUT ±0.3mV Typical Vos**
- **INPUT VOLTAGE RANGE: -0.1V to +5.6V with Vs = 5.5V**
- **SUPPLY RANGE: +2.5V to +5.5V**
- **SPECIFIED UP TO +125°C**
- **Micro SIZE PACKAGES: SOT23-5, MSOP8, DFN2X2-8**

2 APPLICATIONS

- **SENSORS**
- **PHOTODIODE AMPLIFICATION**
- **ACTIVE FILTERS**
- **TEST EQUIPMENT**
- **DRIVING A/D CONVERTERS**

3 DESCRIPTIONS

The RS62X-Q1 families of products offer low voltage operation and rail-to-rail input and output, as well as excellent speed/power consumption ratio, providing an excellent bandwidth (7MHz) and slew rate of 4.3V/µs. The op-amps are unity gain stable and feature an ultra-low input bias current.

The devices are ideal for sensor interfaces, active filters and portable applications. The RS62X-Q1 families of operational amplifiers are specified at the full temperature range of -40°C to 125°C under single or dual power supplies of 2.5V to 5.5V.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
RS621-Q1	SOT23-5	2.92mm×1.62mm
RS622-Q1	MSOP8	3.00mm×3.00mm
	DFN2X2-8	2.00mm×2.00mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

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4 REVISION HISTORY

Note: Page numbers for previous revisions may different from page numbers in the current version.

Version	Change Date	Change Item
A.1	2023/06/16	Initial version completed
A.1.1	2024/03/07	Modify packaging naming
A.2	2025/02/27	1. Delete RS622XK-Q1 Orderable Device 2. Delete relevant information of RS624-Q1

5 PACKAGE/ORDERING INFORMATION [1]

Orderable Device	Package Type	Pin	Channel	Lead finish/Ball material [2]	MSL Peak Temp [3]	Op Temp(°C)	Device Marking [4]	Package Qty
RS621XF-Q1	SOT23-5	5	1	NIPDAUAG	MSL1-260°-Unlimited	-40°C ~125°C	621	Tape and Reel,3000
RS621BXF -Q1	SOT23-5	5	1	NIPDAUAG	MSL1-260°-Unlimited	-40°C ~125°C	621B	Tape and Reel,3000
RS622XM-Q1	MSOP8	8	2	NIPDAUAG	MSL1-260°-Unlimited	-40°C ~125°C	RS622	Tape and Reel,4000
RS622XTDE8 -Q1	DFN2X2-8	8	2	NIPDAUAG	MSL1-260°-Unlimited	-40°C ~125°C	622	Tape and Reel,3000

NOTE:

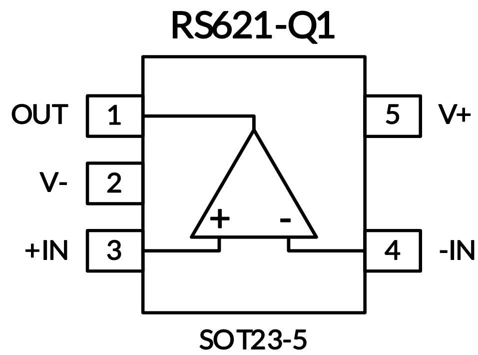
(1) This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the right-hand navigation.

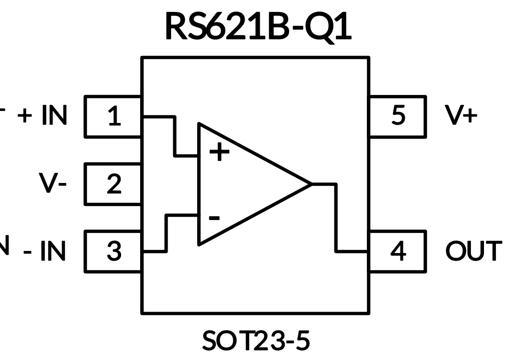
(2) Lead finish/Ball material. Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(3) RUNIC classify the MSL level with using the common preconditioning setting in our assembly factory conforming to the JEDEC industrial standard J-STD-20F, Please align with RUNIC if your end application is quite critical to the preconditioning setting or if you have special requirement.

(4) There may be additional marking, which relates to the lot trace code information (data code and vendor code), the logo or the environmental category on the device.

6 Pin Configuration and Functions (Top View)





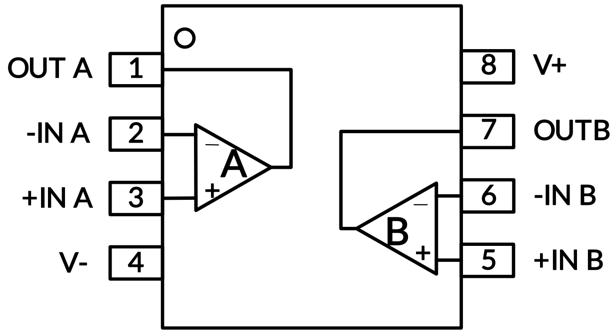
Pin Description

NAME	PIN		I/O (1)	DESCRIPTION
	RS621-Q1	RS621B-Q1		
	SOT23-5	SOT23-5		
-IN	4	3	I	Negative (inverting) input
+IN	3	1	I	Positive (noninverting) input
OUT	1	4	O	Output
V-	2	2	-	Negative (lowest) power supply
V+	5	5	-	Positive (highest) power supply

(1) I = Input, O = Output.

Pin Configuration and Functions (Top View)

RS622-Q1



MSOP8/DFN2X2-8

Pin Description

NAME	PIN	I/O (1)	DESCRIPTION
	RS622-Q1		
	MSOP8/DFN2X2-8		
-INA	2	I	Inverting input, channel A
+INA	3	I	Noninverting input, channel A
-INB	6	I	Inverting input, channel B
+INB	5	I	Noninverting input, channel B
OUTA	1	O	Output, channel A
OUTB	7	O	Output, channel B
V-	4	-	Negative (lowest) power supply
V+	8	-	Positive (highest) power supply

(1) I = Input, O = Output.

7 SPECIFICATIONS

7.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted) (1)

			MIN	MAX	UNIT
Voltage	Supply, V_S=(V+) - (V-)			7	V
	Signal input pin (2)	Common-Mode	(V-) - 0.5	(V+) + 0.5	
		Differential (7)		(V+) - (V-) + 0.2	
	Signal output pin (3)		(V-) - 0.5	(V+) + 0.5	
Current	Signal input pin (2)		-10	10	mA
	Signal output pin (3)		-10	10	
	Output short-circuit (4)		Continuous		
θ_{JA}	Package thermal impedance (5)	SOT23-5		230	°C/W
		MSOP8		170	
		DFN2X2-8		80	
Temperature	Operating range, T_A		-40	125	°C
	Junction, T_J (6)		-40	150	
	Storage, T_{stg}		-65	150	

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.
(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less.
(3) Output terminals are diode-clamped to the power-supply rails. Output signals that can swing more than 0.5V beyond the supply rails should be current-limited to ±10mA or less.
(4) Short-circuit to ground, one amplifier per package.
(5) The package thermal impedance is calculated in accordance with JESD-51.
(6) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{\theta JA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is PD = ($T_{J(MAX)}$ - T_A) / $R_{\theta JA}$. All numbers apply for packages soldered directly onto a PCB.
(7) Differential input voltages greater than 0.5 V applied continuously can result in a shift to the input offset voltage above the maximum specification of this parameter. The magnitude of this effect increases as the ambient operating temperature rises.

7.2 ESD Ratings

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-Body Model (HBM), per AEC Q100-002 (1)	±2000	V
		Charged-Device Model (CDM), per AEC Q100-011	±1000	
		Latch-Up (LU), per AEC Q100-004	±100	mA

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

ESD SENSITIVITY CAUTION

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

7.3 Recommended Operating Conditions

Over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
Supply voltage，V_S= (V+) - (V-)	Single-supply	2.5		5.5	V
	Dual-supply	±1.25		±2.75	

7.4 ELECTRICAL CHARACTERISTICS

(At T_A = +25°C, V_S=2.5V to 5.5V, R_L = 10kΩ connected to V_S/2, and V_{OUT} = V_S/2, V_{CM}=V_S/2, Full [9] = -40°C to +125°C, unless otherwise noted.) [1]

PARAMETER		CONDITIONS	T_J	RS62X-Q1			
				MIN[2]	TYP[3]	MAX[2]	UNIT
POWER SUPPLY							
V_S	Operating Voltage Range		25°C	2.5		5.5	V
I_Q	Quiescent Current Per Amplifier	V_S=±2.5V, Io=0mA	25°C		625	850	μA
			Full			1350	
PSRR	Power-Supply Rejection Ratio	V_S=2.5V to 5.5V	25°C	70	90		dB
			Full	65			
INPUT							
V_{OS}	Input Offset Voltage	V_S = 5V, V_{CM}=V_S/2	25°C	-1.5	±0.3	1.5	mV
			Full	-3		3	
V_{OS} T_C	Input Offset Voltage Average Drift		Full		±2.3		μV/°C
IB	Input Bias Current [4] [5]	V_{CM}=V_S/2	25°C		±1	±10	pA
			Full			±10	nA
I_{OS}	Input Offset Current [5]	V_{CM}=V_S/2	25°C		±1	±10	pA
			Full			±10	nA
V_{CM}	Common-Mode Voltage Range	V_S= 5.5V	25°C	-0.1		5.6	V
CMRR	Common-Mode Rejection Ratio	V_S = 5.5V V_{CM}=-0.1V to 3.5V	25°C	72	94		dB
			Full	65			
		V_S = 5.5V V_{CM}=-0.1V to 5.6V	25°C	60	80		
			Full	56			
OUTPUT							
A_{OL}	Open-Loop Voltage Gain	R_L=10KΩ, V_O=(V-)+0.1V to (V+)-0.1V	25°C	105	127		dB
			Full	98			
	Output Swing From Rail	V_S=±2.5V, R_L=10KΩ	25°C		10	20	mV
			Full			25	
I_{OUT}	Output Short-Circuit Current [6] [7]		25°C	±45	±70		mA
			Full	±25			
C_{LOAD}	Capacitive Load Drive		25°C		100		pF
FREQUENCY RESPONSE							
SR	Slew Rate [8]	G=+1, C_L=100pF	25°C		4.3		V/μs
GBP	Gain-Bandwidth Product		25°C		7		MHz
PM	Phase Margin [5]		25°C		64		°
ts	Settling Time,0.1%	V_S=±2.5V, G=+1, C_L=100pF, Step=2V	25°C		1.9		μs
t_{OR}	Overload Recovery Time	V_{IN}·Gain≥V_S, G=-10	25°C		0.45		μs
NOISE							
E_n	Input Voltage Noise	f = 0.1Hz to 10Hz, V_S=±2.5V	25°C		3.6		$μV_{PP}$
en	Input Voltage Noise Density	V_S=±2.5V, f = 10KHz	25°C		13		$nV/\sqrt{Hz}$
		V_S=±2.5V, f = 1KHz	25°C		14		$nV/\sqrt{Hz}$

NOTE:

(1) Electrical table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device.

(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.

(3) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.

(4) Positive current corresponds to current flowing into the device.

(5) This parameter is ensured by design and/or characterization and is not tested in production.

(6) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{\theta JA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is PD = ($T_{J(MAX)}$ - T_A) / $R_{\theta JA}$. All numbers apply for packages soldered directly onto a PCB.

(7) Short circuit test is a momentary test.

(8) Number specified is the slower of positive and negative slew rates.

(9) Specified by characterization only.

7.5 TYPICAL CHARACTERISTICS

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

At T_A = +25°C, V_S=5V, R_L = 10kΩ connected to $V_S/2$, V_{OUT} = $V_S/2$, unless otherwise noted.

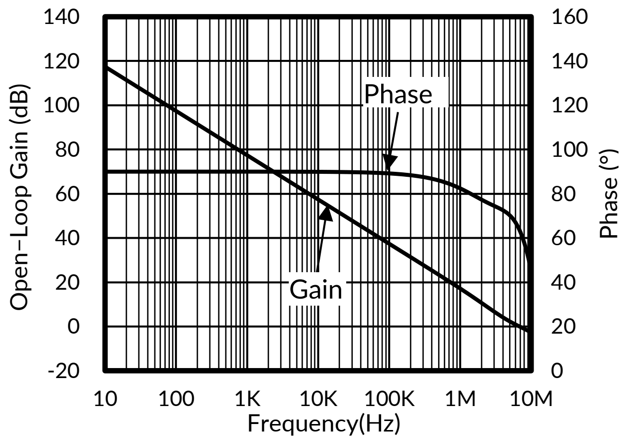


Figure 1. Open−Loop Gain and Phase vs Frequency

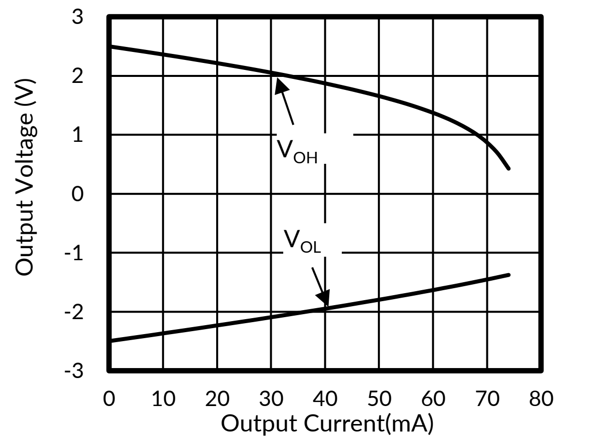


Figure 2. Output Voltage Swing vs Output Current

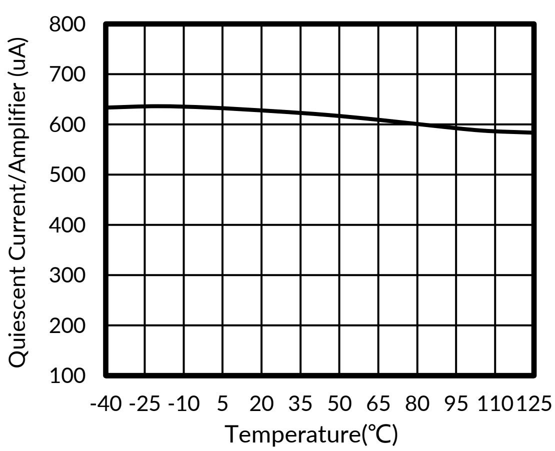


Figure 3. Quiescent Current vs Temperature

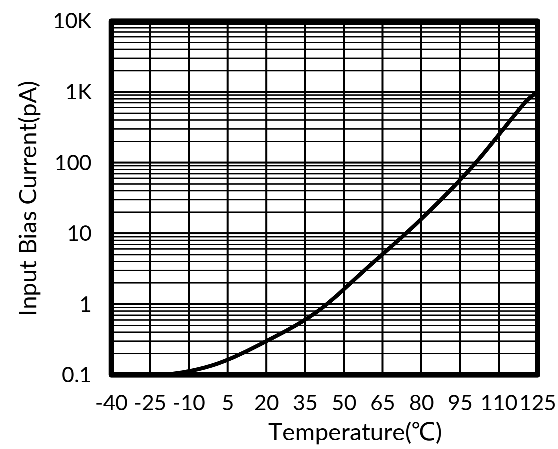


Figure 4. Input Bias Current vs Temperature

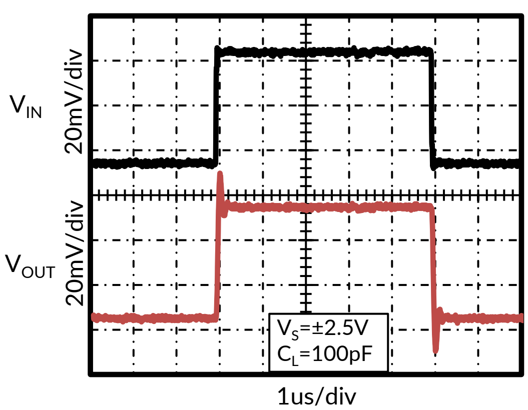


Figure 5. Small-Signal Step Response

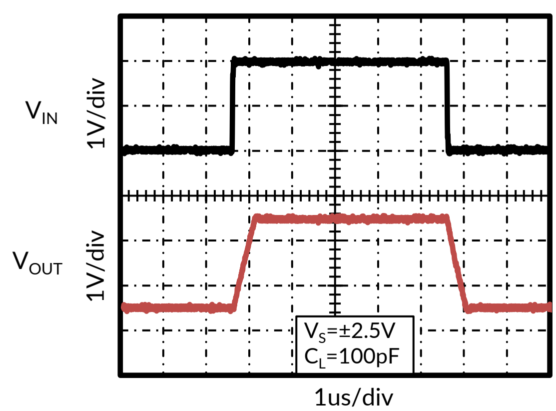


Figure 6. Large-Signal Step Response

TYPICAL CHARACTERISTICS

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

At T_A = +25°C, V_S=5V, R_L = 10kΩ connected to V_S/2, V_{OUT} = V_S/2, unless otherwise noted.

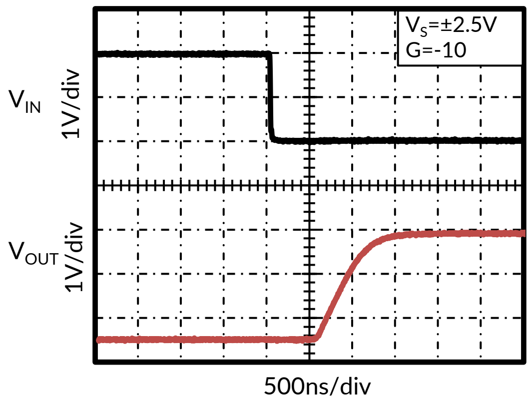


Figure 7. Negative Overvoltage Recovery

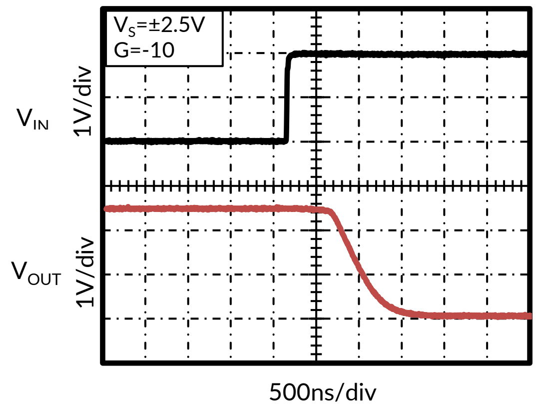


Figure 8. Positive Overvoltage Recovery

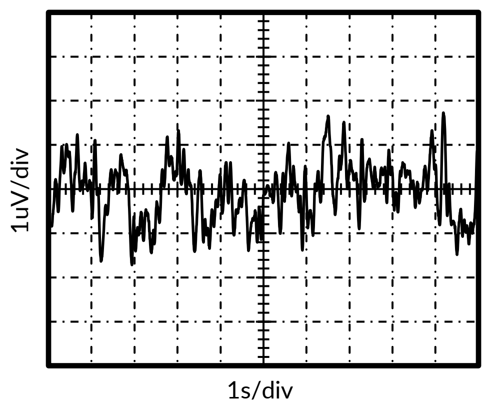


Figure 9. 0.1Hz to 10Hz Input Voltage Noise

8 Detailed Description

8.1 Overview

The RS621-Q1, RS622-Q1 are high precision, rail-to-rail operational amplifiers that can be run from a single-supply voltage 2.5V to 5.5V (±1.25V to ±2.75V). Supply voltages higher than 7V (absolute maximum) can permanently damage the amplifier. Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications. Good layout practice mandates use of a 0.1uF capacitor place closely across the supply pins.

8.2 Phase Reversal Protection

The RS62X-Q1 family has internal phase-reversal protection. Many op amps exhibit phase reversal when the input is driven beyond the linear common-mode range. This condition is most often encountered in noninverting circuits when the input is driven beyond the specified common-mode voltage range, causing the output to reverse into the opposite rail. The input of the RS62X-Q1 prevents phase reversal with excessive common-mode voltage. Instead, the appropriate rail limits the output voltage. This performance is shown in figure 10.

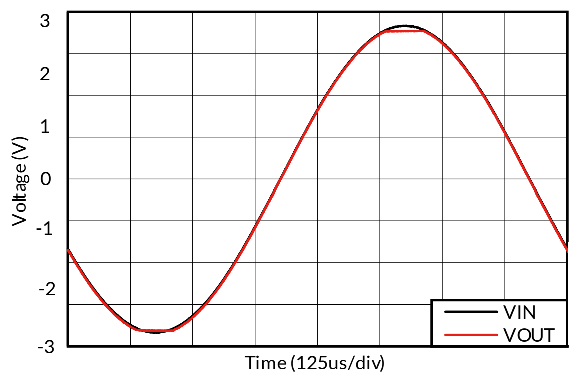


Figure 10. Output Waveform Devoid of Phase Reversal During an Input Overdrive Condition

8.3 EMIRR IN+ Test Configuration

Figure 11 shows the circuit configuration for testing the EMIRR IN+. An RF source is connected to the operational amplifier noninverting input pin using a transmission line. The operational amplifier is configured in a unity-gain buffer topology with the output connected to a low-pass filter (LPF) and a digital multimeter (DMM). A large impedance mismatch at the operational amplifier input causes a voltage reflection; however, this effect is characterized and accounted for when determining the EMIRR IN+. The resulting dc offset voltage is sampled and measured by the multimeter. The LPF isolates the multimeter from residual RF signals that can interfere with multimeter accuracy.

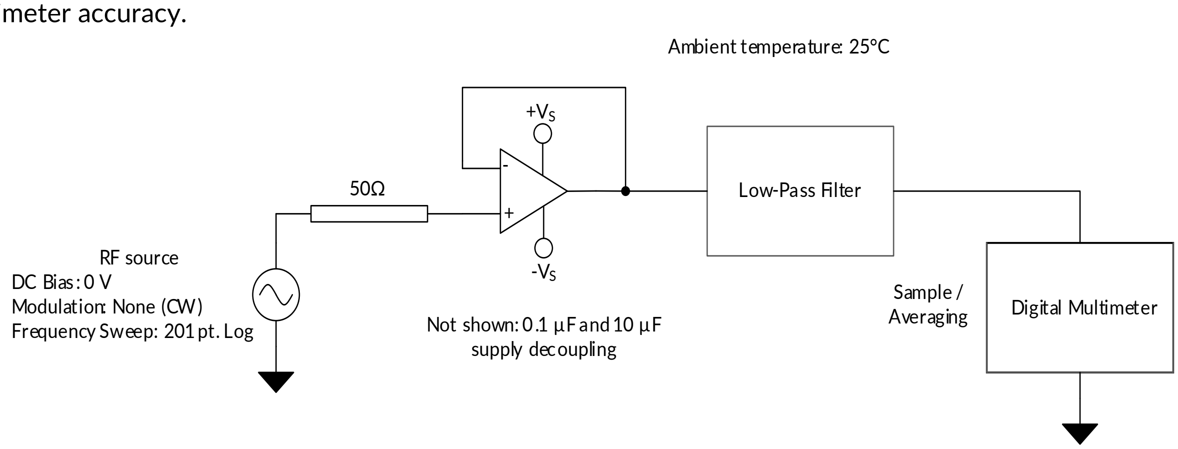


Figure 11. EMIRR IN+ Test Configuration Schematic

9 Application and Implementation

Information in the following applications sections is not part of the RUNIC component specification, and RUNIC does not warrant its accuracy or completeness. RUNIC's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 APPLICATION NOTE

The RS62X-Q1 are high precision, rail-to-rail operational amplifiers that can be run from a single-supply voltage 2.5V to 5.5V (±1.25V to ±2.75V). Supply voltages higher than 7V (absolute maximum) can permanently damage the amplifier. Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications. Good layout practice mandates use of a 0.1uF capacitor place closely across the supply pins.

Typical Applications

9.2 25-kHz Low-pass Filter

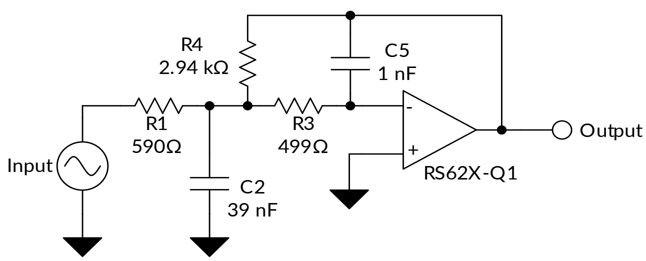


Figure 12. 25-kHz Low-Pass Filter

9.3 Design Requirements

Low-pass filters are commonly employed in signal processing applications to reduce noise and prevent aliasing. The RS62X-Q1 devices are ideally suited to construct high-speed, high-precision active filters. Figure 12 shows a second-order, low-pass filter commonly encountered in signal processing applications.

Use the following parameters for this design example:

- Gain = 5 V/V (inverting gain)
- Low-pass cutoff frequency = 25 kHz
- Second-order Chebyshev filter response with 3-dB gain peaking in the passband

9.4 Detailed Design Procedure

The infinite-gain multiple-feedback circuit for a low-pass network function is shown in Figure 12. Use Equation 1 to calculate the voltage transfer function.

$$\frac{Output}{Input}(s) = \frac{-1/R_1R_3C_2C_5}{s^2 + (s/C_2)(1/R_1 + 1/R_3 + 1/R_4) + 1/R_3R_4C_2C_5} \quad (1)$$

This circuit produces a signal inversion. For this circuit, the gain at dc and the low-pass cutoff frequency are calculated by Equation 2:

$$Gain = \frac{R_4}{R_1}$$

$$f_C = \frac{1}{2\pi}\sqrt{(1/R_3R_4C_2C_5)} \quad (2)$$

9.5 Application Curve

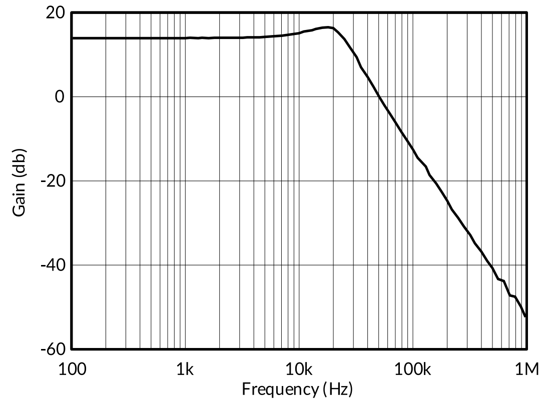


Figure 13. Low-pass filter transfer function

10 LAYOUTS

10.1 Layout Guidelines

Attention to good layout practices is always recommended. Keep traces short. When possible, use a PCB ground plane with surface-mount components placed as close to the device pins as possible. Place a 0.1uF capacitor closely across the supply pins.

These guidelines should be applied throughout the analog circuit to improve performance and provide benefits such as reducing the EMI susceptibility.

10.2 Layout Example

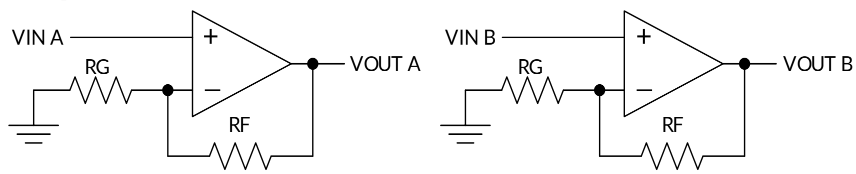


Figure 14. Schematic Representation

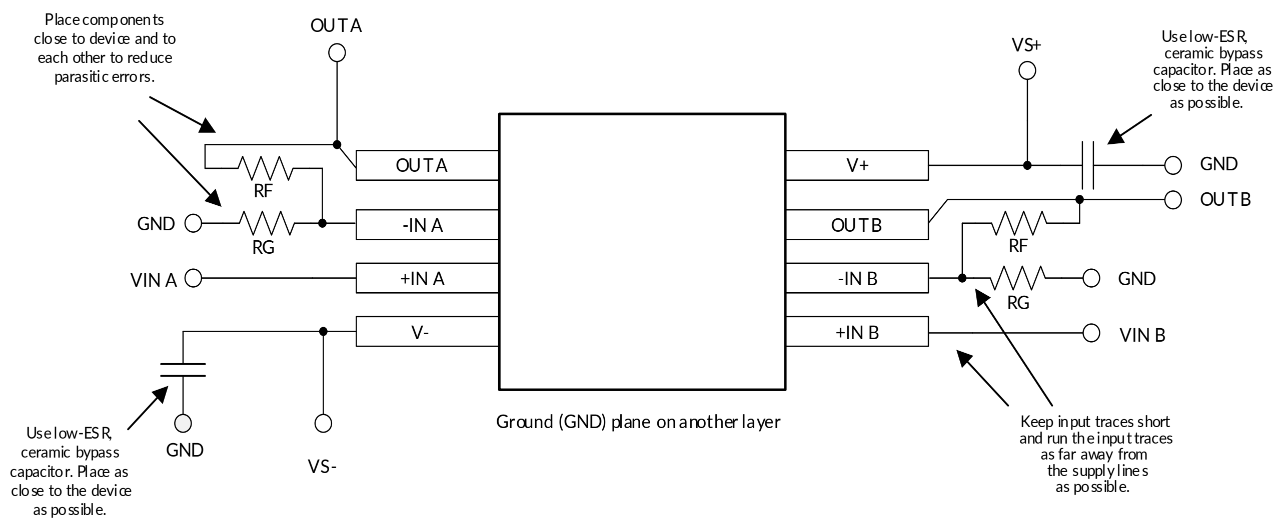
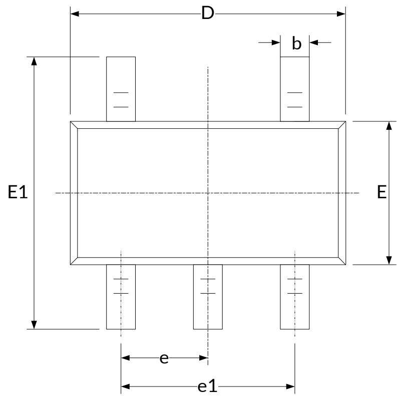


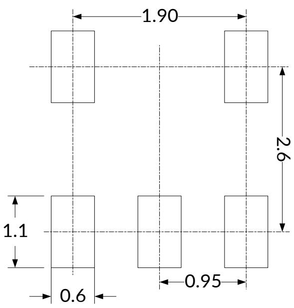
Figure 15. Layout Example

NOTE: Layout Recommendations have been shown for dual op-amp only, follow similar precautions for Single and four.

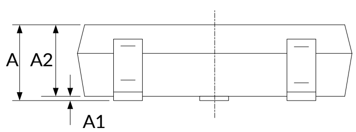
11 PACKAGE OUTLINE DIMENSIONS

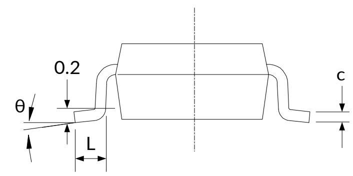
SOT23-5 (3)





RECOMMENDED LAND PATTERN (Unit: mm)



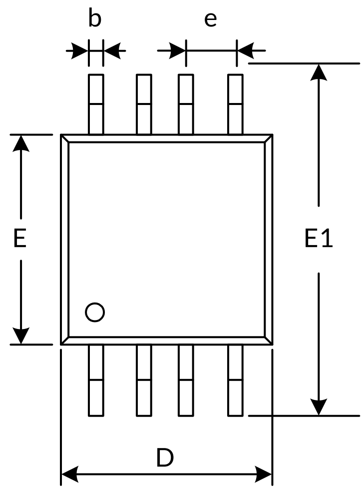


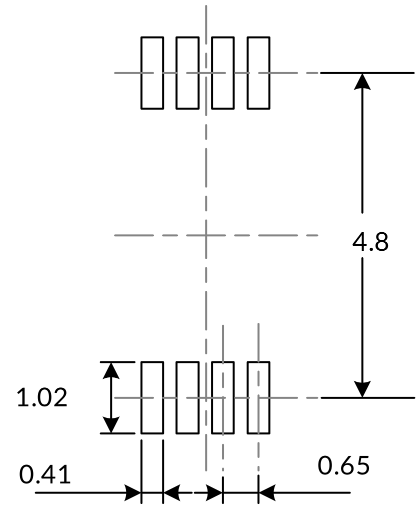
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)		1.250		0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.360	0.500	0.014	0.020
c	0.100	0.200	0.004	0.008
D (1)	2.826	3.026	0.111	0.119
E (1)	1.526	1.726	0.060	0.068
E1	2.600	3.000	0.102	0.118
e	0.950(BSC) (2)		0.037(BSC) (2)	
e1	1.800	2.000	0.071	0.079
L	0.350	0.600	0.014	0.024
θ	0°	8°	0°	8°

NOTE:

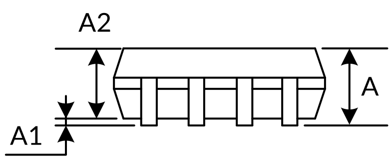
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

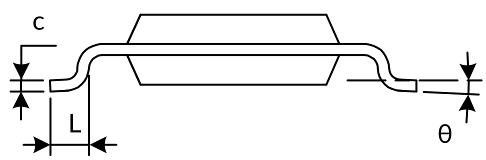
MSOP8 (3)





RECOMMENDED LAND PATTERN (Unit: mm)

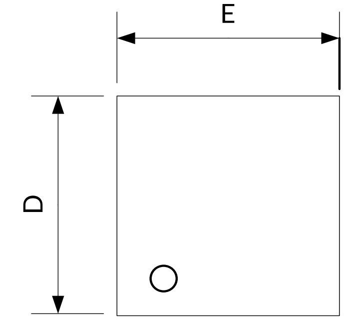




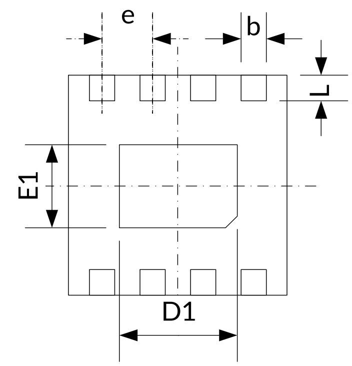
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D (1)	2.900	3.100	0.114	0.122
e	0.650(BSC) (2)		0.026(BSC) (2)	
E (1)	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

NOTE:
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

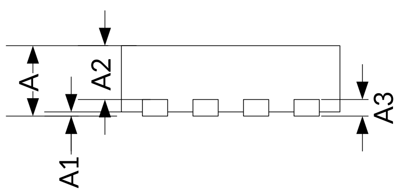
DFN2X2-8 (4)



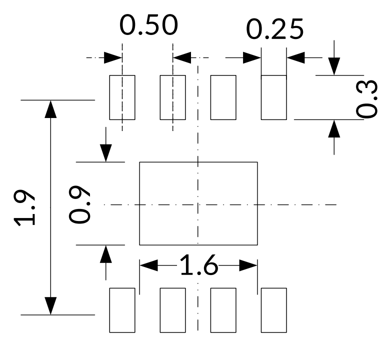
TOP VIEW



BOTTOM VIEW



SIDE VIEW



RECOMMENDED LAND PATTERN (Unit: mm)

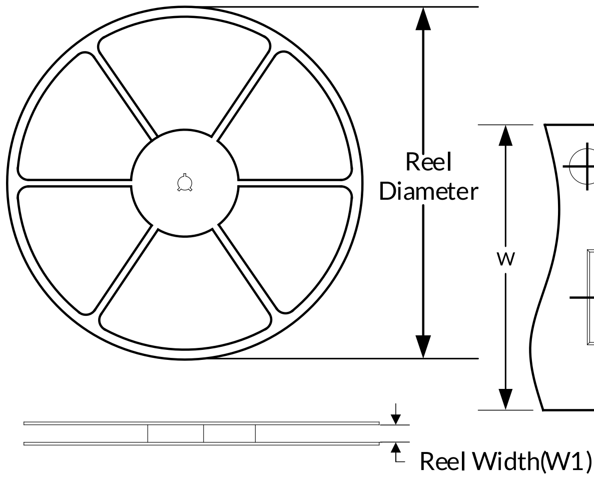
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.500	0.600	0.020	0.024
A3	0.203 REF (2)		0.008 REF (2)	
b	0.200	0.300	0.007	0.012
D (1)	1.950	2.050	0.076	0.081
D1	1.550	1.650	0.061	0.065
E (1)	1.950	2.050	0.076	0.081
E1	0.850	0.950	0.033	0.037
e	0.500 BSC (3)		0.020 BSC (3)	
L	0.250	0.350	0.010	0.014

NOTE:

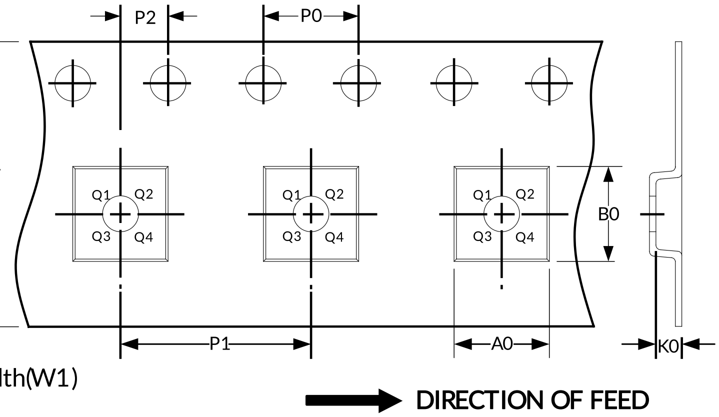
1. Plastic or metal protrusions of 0.075mm maximum per side are not included.
2. REF is the abbreviation for Reference.
3. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
4. This drawing is subject to change without notice.

12 TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSION



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width(mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT23-5	7"	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
MSOP8	13"	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1
DFN2X2-8	7"	9.5	2.30	2.30	1.10	4.0	4.0	2.0	8.0	Q2

NOTE:
1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

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